



# SCIENCE 7

**LEARNING FACILITATOR'S  
MANUAL**



## **MODULE 4: TEMPERATURE AND HEAT**



**Distance  
Learning**

**Alberta**  
EDUCATION





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## **Module 4**

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## ACKNOWLEDGEMENTS

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Cover photographs courtesy of Dave Mussell, Edmonton.

### Note

This Science Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final tests until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

Science 7  
Learning Facilitator's Manual  
Module 4  
Temperature and Heat  
Alberta Distance Learning Centre  
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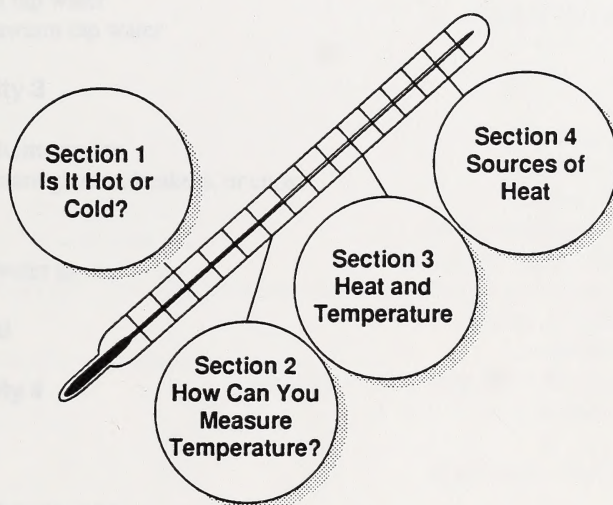
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## Module 4 - Temperature and Heat: Overview

The major emphasis of this module is on the nature of science. However, opportunities are also present for students to apply their science knowledge to the solving of practical problems and to better understand the relationship among science, technology, and society. Students continue to discover how scientists work – by observing, asking questions, performing experiments, and providing explanations for their observations.

Module 4 examines the effects of heat and temperature changes with particular attention to methods of measuring these. The need for accuracy and the need for specialized thermometers are part of this module.

In this module, students study the effects of heating and cooling water, and learn to distinguish between heat and temperature. Students determine how the energy content of various foods and fuels can be measured, and study the uses of various sources of heat which include chemical, mechanical, electrical, geothermal, and solar energy.



### Caution

A number of activities in this module involve the use of hot plates or flames. These activities should all be done with the advice and supervision of the learning facilitator.



## Evaluation

The student's successful completion of all assignments will depend on practice obtained while doing the various activities. Many choices of activities have been provided so that students have some control over their own learning.

The following distribution of marks is suggested in determining the student's grading for this module.

Section 1 Assignment	12 %
Section 2 Assignment	32 %
Section 3 Assignment	26 %
Section 4 Assignment	<u>30 %</u>
<b>TOTAL</b>	<b>100 %</b>

Although the value of each module for the Science 7 course is the decision of the classroom teacher, it is suggested that Module 4 be worth 12% of the total final grade, based on equal weighting of the six modules in this course, plus a final test.

## Materials Needed for Module 4

### Comment:

For a complete overview of the materials needed for Module 4 and how the topics are developed, it may be helpful to preview the contents of Module 4. In some cases if the materials suggested are not readily available, the learning facilitator may be able to substitute suitable materials for the student, so that the activities can be completed successfully.

The materials needed for Module 4 and the activities in which they are to be used are as follows:

### Section 1: Activity 1

- 14 index cards

### Section 1: Activity 2

- a bowl of hot tap water
- a bowl of cold tap water
- a bowl of lukewarm tap water

### Section 1: Activity 3

- uncalibrated thermometer
- four heat-resistant glasses, beakers, or cups
- water
- ice
- kettle to boil water in
- masking tape
- marking pencil

### Section 1: Activity 4

#### Part B:

- uncalibrated thermometer
- masking tape
- marker
- water
- ice cubes
- beaker or cooking pot
- beaker or drinking glass
- oven mitt
- ruler
- hot plate or stove

**Section 1: Extra Help**

- laboratory thermometer (with scale from below 0°C to above 100°C)

**Section 2: Activity 3**

- round balloon
- string
- ruler
- felt marker

**Section 2: Activity 4****Part A:**

- bimetallic strip, with a handle
- heat source with a flame

**Section 2: Activity 5****Part A:**

- water
- cooking oil
- glycerine
- hot plate (or stove)
- three large test tubes
- three one-holed stoppers, each with a long piece of clear plastic tubing inserted
- 500 mL beaker
- stirring rod
- support stand and clamps (optional)
- masking tape

**Section 2: Activity 6****Part A:**

If students choose to do Part A they will need three different thermometers (at least one solid and one liquid thermometer). Aside from liquid and spring-type weather thermometers, choices might include specialized thermometers such as a clinical thermometer, liquid crystal thermometer, oven thermometer, or a thermostat.



## Section 2: Enrichment

- round-bottomed flask
- 30 cm of transparent rigid plastic tube
- one-holed stopper
- large beaker or container
- coloured water (at room temperature)
- support stand
- clamp
- masking tape

## Section 3: Activity 1

- water
- thermometer, with a range to 100°C
- graduated cylinder or measuring cup
- hot plate or stove
- beaker
- support stand (optional)
- two clamps (optional)
- timer

## Section 3: Activity 2

- hot plate or stove
- beaker, heat resistant cup, or small pan
- thermometer, with a range to 100°C
- graduated cylinder or measuring cup
- water
- cooking oil
- glycerine (glycerol) or anti-freeze
- support stand (optional)
- two clamps (optional)
- timer

## Section 3: Activity 5

- two cups or beakers
- uncalibrated thermometer
- 100 mL graduated cylinder or measuring cup
- cold water
- hot water from tap
- stirring rod, stir stick, or spoon
- masking tape

**Section 3: Activity 6**

- two cups or beakers
- uncalibrated thermometer
- 100 mL graduated cylinder or measuring cup
- cold water
- hot water from tap
- stirring rod, stir stick, or spoon
- masking tape

**Section 3: Activity 7**

- two cups or beakers
- uncalibrated thermometer
- 100 mL graduated cylinder or measuring cup
- cold water
- hot water from tap
- cooking oil
- masking tape
- stirring rod, stir stick, or spoon

**Section 3: Enrichment****Part A:**

- thermometer
- beaker or cup
- timer
- water
- freezer

**Section 4: Activity 1****Part A:**

- a shelled peanut
- a shelled walnut
- pin embedded in a cork or eraser
- two empty pop cans
- graduated cylinder or measuring cup
- oven mitt
- thermometer
- matches
- safety glasses
- water
- aluminum foil



## Section 4: Activity 2

### Friction:

- brick (or piece of concrete)
- large nail

### Bending:

- paper clip

### Pounding:

- wooden block
- hammer

## Section 4: Enrichment

- birthday candle
- large candle
- two empty pop cans
- thermometer
- oven mitt
- timer
- graduated cylinder or measuring cup
- water

## Section 1: Is It Hot or Cold?

By the end of this section students should be able to

- infer temperatures based on physical properties
- compare temperatures of materials without using numbers
- make a temperature scale
- describe the Celsius temperature scale

## Section 1: Activity 1

### Comments:

The aim of this activity is to see how much the student already knows about temperature. The temperatures in a number of different situations are to be estimated.

Check to see that the student has followed the instructions given and has completed the charts for questions 1 and 2. (If the student couldn't find the actual temperatures for the items by library research, then you can give these temperatures to the student. The actual temperature of each item is shown in brackets in the answers given in the chart for question 2.)

1. Record the order you decided upon in the following chart.

<b>Estimated Order from Hottest to Coldest</b>		
hottest	• _____	• _____
	• _____	• _____
<i>Answers will vary. These estimates do not need to be marked; the purpose of the exercise is to start students thinking in preparation for question 2.</i>		
	• _____	• _____
	• _____	• _____
	• _____	• _____
		coldest

2. In the following chart, list the items again in the actual order from hottest to coldest.

*To assist the marker, the actual temperature of each item is shown in brackets. This is not a required part of the student answer.*

<b>Actual Order from Hottest to Coldest</b>		
hottest	• interior of sun (15 000 000°C)	• body temperature (37°C)
	• surface of sun (6000°C)	• room temperature (20°C)
	• oven temperature (165°C)	• air in refrigerator (1 to 3°C)
	• boiling water (100°C)	• temperature at which water freezes (0°C)
	• hot tea (80°C)	• ice cream (– 5° to – 10°C)
	• hottest air temperature (58°C)	• coldest air temperature (– 88°C)
	• bath or shower (40°C)	• lowest temperature possible (– 273°C)
		coldest

## Section 1: Activity 2

### Questions to Answer

1. How did the hand that was in the hot water feel when it was put in the lukewarm water?

*That hand felt cool (or the water felt cool).*



2. How did the hand that was in the cold water feel when it was put in the lukewarm water?

*That hand felt warm (or the water felt warm).*

3. a. Is touch a reliable indicator of temperature?

*No, touch is not a reliable indicator of temperature.*

- b. Why or why not?

*Answers will vary. The following two answers are example answers:*

*The way the temperature feels depends on the situation. or*

*What feels warm in one situation may feel cold in another situation.*

### Section 1: Activity 3

#### Questions to Answer

1. a. Which glass contained the hottest water?

*Glass 4 contained the hottest water.*

- b. How was this shown by the thermometer?

*The liquid in the thermometer was highest when the thermometer was placed in this glass.*

2. a. Which glass contained the coldest water?

*Glass 1 contained the coldest water.*

- b. How was this shown by the thermometer?

*The liquid in the thermometer was lowest when the thermometer was placed in this glass.*

3. List the glasses from hottest to coldest.

hottest      glass 4

                glass 3

                glass 2

coldest      glass 1

4. Why is a thermometer more accurate than using your senses to estimate temperature?

*Answers will vary. The key idea that should be brought out in the student answer is the idea of objectivity. The following two answers are examples:*

*The temperature does not depend on how you feel. or*

*You can measure exactly how warm or cold the water is.*

## Section 1: Activity 4

**Note:** Students are to do either Part A or Part B.

### Part A: Calibrating Your Thermometer by Your Own Method

How can you make your uncalibrated thermometer into a calibrated thermometer? In this part of the activity, you must think about how you would change your thermometer so you could measure the temperature in degrees.

How would you go about doing this? What would you do first? What would you do next? If you need help, you may want to reread and think about what Anders Celsius did.

Follow the instructions and answer the questions.

1. After you have thought about it, make a list on a separate piece of paper of the steps you would use. When you are sure that you have all the steps you need, in suitable order, write them in the following space.

*Answers will vary. One approach that might be used is as follows:*

- *Place the thermometer in a container of ice water.*
- *Put some tape on the thermometer and mark the temperature of the ice water as 0°C (for the level when the thermometer is placed in the ice water).*
- *Place the thermometer in boiling water.*
- *Mark the temperature as 100°C.*
- *Mark the halfway point as 50°C.*
- *Mark halfway between 0°C and 50°C as 25°C.*
- *Continue to add marks on the thermometer for every 5°C by dividing each 25 degree space into five spaces.*



*Another more simple approach which students might use is as follows:*

- *Obtain a calibrated thermometer to use as a comparison.*
- *Place the calibrated thermometer and the uncalibrated thermometer in cold water.*
- *Read the temperature on the calibrated thermometer; then make a mark on the uncalibrated thermometer so it reads the same.*
- *Place the thermometers in somewhat warmer water.*
- *Read the new temperature on the calibrated thermometer; then make a new mark on the uncalibrated thermometer to show this new temperature.*
- *Continue steps 4 and 5 until as many markings as desired are shown.*

2. Show your proposed method to your learning facilitator and make any changes that are suggested.

*Check the student's method and suggest how improvements can be made, if any are needed. The example answers given for question 1 can serve as a guide.*

3. Collect your materials.

*Check to see that the student has the necessary materials.*

4. Calibrate your thermometer.

*Check to see that the student has calibrated a thermometer. If this is done well, then a reasonably accurate answer should be given to question 5.*

5. What is the temperature of the room you are in?

*Answers will vary. A temperature range of 18°C to 23°C is normal.*

## **Part B: Calibrating Your Thermometer by Following Directions**

Comments:

If the student chooses Part B, check to see how well the instructions to calibrate the thermometer given in steps 1 to 8 in the Module Booklet were followed.

6. What is the temperature of the room you are in?

*The answers will vary. A temperature range of 18°C to 23°C is normal.*

## Section 1: Follow-up Activities

### Extra Help

#### Caution

A glass thermometer breaks easily. Handle it carefully.

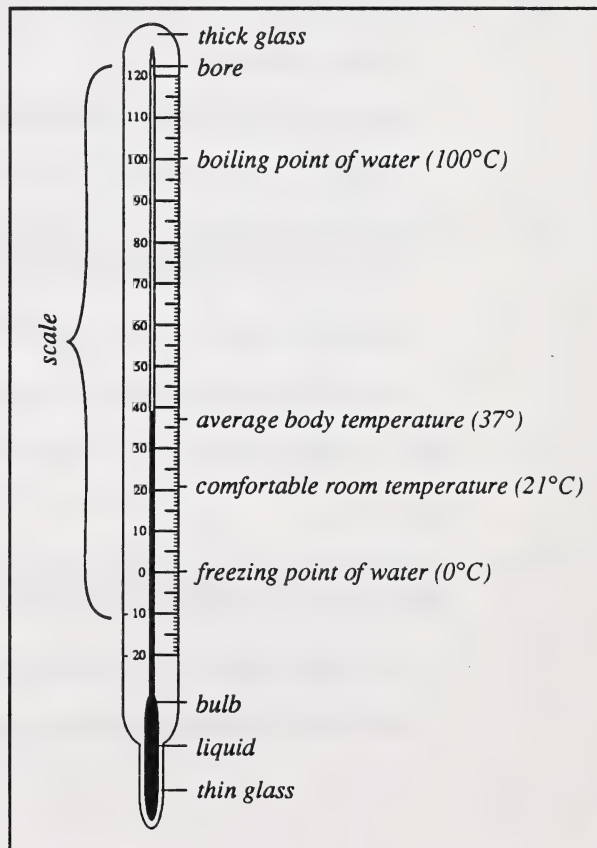
#### Comments:

For this Extra Help activity, the student is to examine a laboratory thermometer with a scale from below  $0^{\circ}\text{C}$  to above  $100^{\circ}\text{C}$ . Remind students to handle laboratory thermometers carefully as they break easily.

1. Examine the thermometer carefully. Notice where the glass is thick and where it is thin. Draw a diagram of the thermometer in the box on the right.

Add the following labels on your diagram:

- liquid (coloured alcohol)
- bore (the fine opening through which the liquid moves)
- thick glass
- thin glass
- bulb (storage space for the liquid)
- scale
- freezing point of water ( $0^{\circ}\text{C}$ )
- boiling point of water ( $100^{\circ}\text{C}$ )
- comfortable room temperature ( $21^{\circ}\text{C}$ )
- average normal body temperature ( $37^{\circ}\text{C}$ )





2. What happens to the temperature reading if you place your hand around the middle of the thermometer?

*There is no change in temperature.*

3. What happens to the temperature reading if you place your hand around the bulb?

*The temperature rises.*

4. The bulb is considered to be an important part of a liquid thermometer. Give a possible reason why.

*Answers will vary. The following two answers are examples:*

*The bulb is the part that is sensitive to temperature. or*

*The bulb is the part with most of the liquid.*

5. a. Which part of the thermometer has the thinnest glass?

*The bulb (bottom of the thermometer) has the thinnest glass.*

- b. Why do you think it is made this way?

*Answers will vary. The actual reason is to allow the thermometer liquid to adjust rapidly to the temperature of the material in which the thermometer is placed.*

6. How many Celsius degrees are there between the freezing point of water and the boiling point of water?

*There are 100 Celsius degrees difference between the boiling point and the freezing point of water.*

7. Why do you think that coloured alcohol was used in the thermometer instead of coloured water?

*Answers will vary. The actual reason is two-fold. Firstly, there is a problem in that water would not give a temperature reading below 0°C or above 100°C. Secondly, if the temperature were reduced to below freezing, the bulb would break.*

8. Why should you not put this thermometer into a liquid at 300°C?

*The thermometer is not constructed for a temperature this high; it would break.*

### Enrichment

1. Use reference books to find the following temperatures for the Celsius scale and for the Fahrenheit scale (developed by Gabriel Fahrenheit). Fill in the following chart.

*Where a range of answers is shown, any answer in this range is acceptable.*

	Temperature in Degrees Celsius	Temperature in Degrees Fahrenheit
temperature at which water freezes	0°C	32°F
temperature at which ice melts	0°C	32°F
temperature at which water boils	100°C	212°F
temperature of a hot summer day	23°C to 33°C	75°F to 90°F
temperature of a cold winter day	-35°C to -20°C	-30°F to -5°F
comfortable room temperature	21°C	72°F
average normal body temperature	37°C	98.6°F

- a. Who was the Fahrenheit scale named after?

*Gabriel Fahrenheit*

- b. What two fixed points were used when the Fahrenheit scale was first made?

low point:

*coldest temperature of ice-salt water mixture (0°F)*

high point:

*human body temperature (96°F)*

*Originally Daniel Fahrenheit took the temperature of an ice and salt mixture as the zero of his scale and the value of 96° for normal body temperature. Later experiments showed normal body temperature to be higher than this and normal body temperature was adjusted to 98.6°F on the final scale.*

*On the Fahrenheit scale 32°F was the freezing point of water and 212°F was the boiling point of water. The interval between these two points was then divided into 180 parts.*



### Changing Celsius Readings to Fahrenheit Readings

2. Change each of these Celsius measurements to Fahrenheit measurements.

- a. The freezing point of water is  $0^{\circ}\text{C}$  or  $32^{\circ}\text{F}$ .
- b. The boiling point of water is  $100^{\circ}\text{C}$  or  $212^{\circ}\text{F}$ .
- c. Average normal body temperature is  $37^{\circ}\text{C}$  or  $98.6^{\circ}\text{F}$ .

### Changing Fahrenheit Readings to Celsius Readings

3. Change each of these Fahrenheit measurements to Celsius measurements.

- a. Comfortable room temperature is  $70^{\circ}\text{F}$  or  $21^{\circ}\text{C}$ .
- b. A hot summer day is  $86^{\circ}\text{F}$  or  $29^{\circ}\text{C}$ .
- c. A very cold winter day is  $-40^{\circ}\text{F}$  or  $-40^{\circ}\text{C}$ .

### Section 1 Assignment

(12 Total Possible Marks)

Comments:

Although the value assigned to each question is the decision of the classroom teacher, suggested values are given in brackets as a guide.

1. Marco slowly enters a swimming pool. He thinks the water is too cool for swimming. After a couple of minutes in the pool, he thinks the temperature is just fine. Explain why he changed his mind. (3)

*The temperature you feel depends on what your body is accustomed to. At first, the water feels cold because Marco's body is not accustomed to it.*

2. What is temperature? (2)

*Temperature is a measure of the hotness or coldness of a material. It is the measure of the average energy of a material.*

3. What is a thermometer? (2)

*A thermometer is a measuring instrument that is designed to measure temperature.*

4. What is a temperature scale? (2)

*A temperature scale is a set of numbered markings used to describe temperature.*

5. Why are temperature scales useful? (3)

*They provide a reliable way of measuring temperature. (They provide a means for measuring temperature objectively. They do not depend on how someone feels.)*

## Section 2: How Can You Measure Temperature?

By the end of this section students should be able to

- classify matter as a solid, a liquid, or a gas
- predict changes in materials due to heating and cooling
- compare the amount of thermal expansion for different materials
- describe how liquid and air thermometers work
- identify several specialized thermometers and describe how they work

### Section 2: Activity 1

1. What are the three states of matter?

- *gas*
- *liquid*
- *solid*

2. Which states of matter can flow?

*Liquids and gases can flow.*

3. Which states of matter cannot be compressed?

*Solids and liquids cannot be compressed.*

4. What does volume mean?

*The volume of a material is the amount of space it occupies.*

5. What does compressed mean?

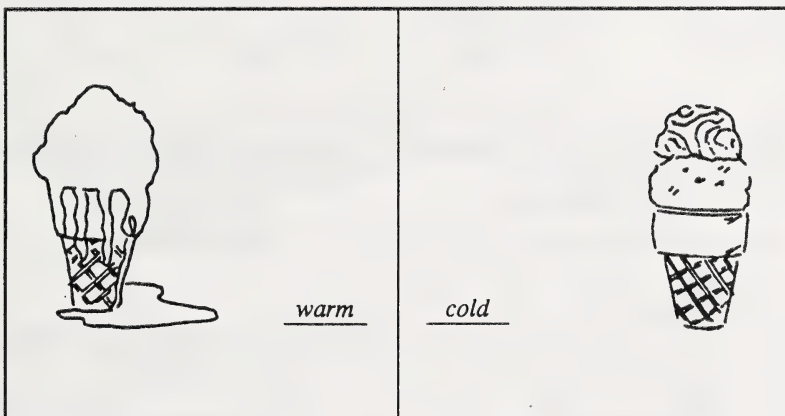
*Compressed means to be squeezed to fit (in a limited space).*

## Section 2: Activity 2

For the following situations, an object has been pictured twice. In each situation you are to identify when the object is hot and when it is cold. Write *hot*, *warm*, or *cold* in each space. This should be very easy to do.

Once you have done this, briefly describe what evidence you used to interpret the temperature in each situation. If there is more than one kind of evidence, be sure to describe all the evidence you see.

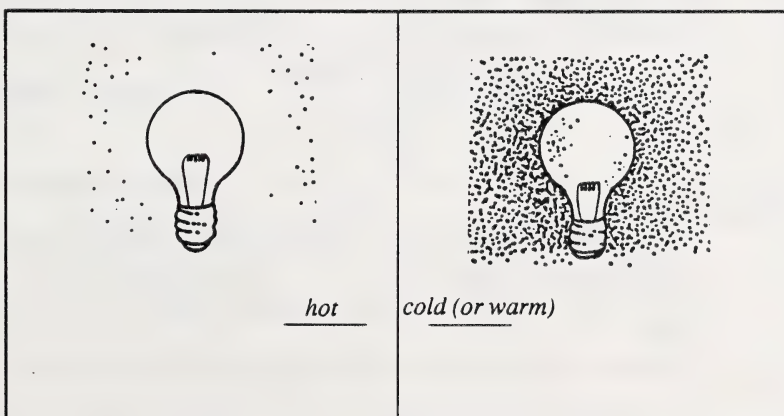
### 1. Ice Cream Cones



Evidence: *The ice cream is melting.*

Evidence: *The ice cream has not melted.*

### 2. Light Bulbs

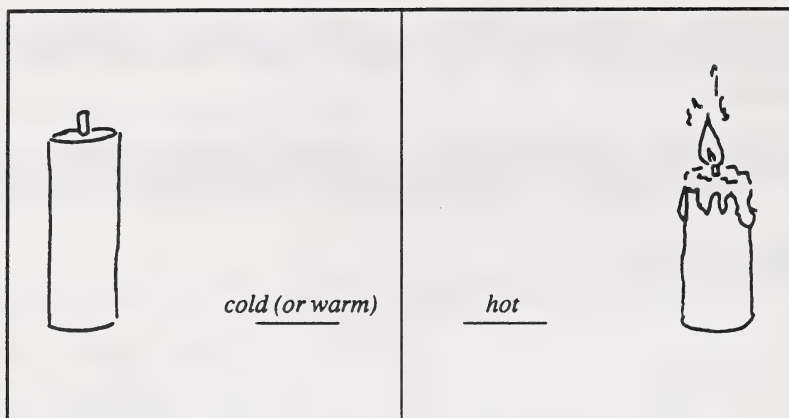


Evidence: *The light bulb is lit up.*

Evidence: *The light bulb is not lit.  
It is at room temperature.*



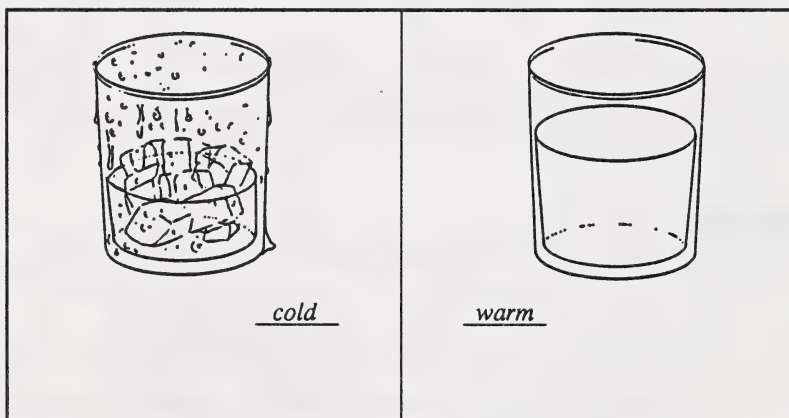
## 3. Candles



Evidence: *The candle is not lit. None of the wax has melted.*

Evidence: *The candle is lit. Some of the wax near the flame has melted.*

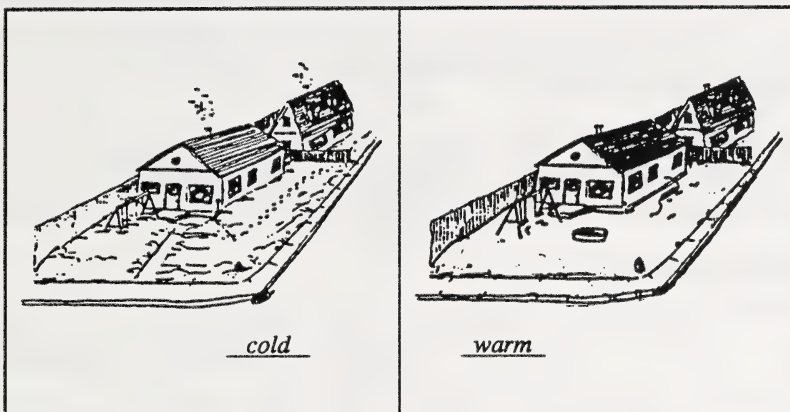
## 4. Drinking Glasses



Evidence: *The water is cooled by ice. Water droplets on the outside of the glass show that the glass is cold.*

Evidence: *The water has no ice in it. There are no droplets of water on the outside of the glass.*

## 5. Weather



Evidence: *The yard is covered with snow. There is smoke rising from the chimneys.*

Evidence: *There is no snow, and no smoke is rising from the chimneys. A child's swimming pool is shown in the yard.*

## Section 2: Activity 3

## Observations

Condition of Balloon	Circumference (cm)
room temperature	<i>Answers will vary. The circumference of the balloon at room temperature should fall between the other two measurements.</i>
refrigerator/freezer temperature	
hot water temperature	

## Questions to Answer

1. What happens to the circumference of the balloon when it is cooled?

*The circumference is less when the balloon is cooled.*

2. What happens to the circumference of the balloon when it is heated?

*The circumference becomes greater when the balloon is heated.*

3. Write a statement about what the size of the balloon can show you about the temperature.

*The warmer the temperature, the larger the balloon becomes; the lower the temperature, the smaller the balloon becomes.*

4. How could a balloon be used as a thermometer?

*If you measured the size of the balloon, this would provide a way of measuring temperature.*

## Section 2: Activity 4

Note: Students are to do either Part A or Part B.

### Comments:

Students should be encouraged to do Part A if a bimetallic strip with a handle is available. A candle can be used as the heat source. Since an open flame is being used, see that proper safety precautions are being followed.

### Part A

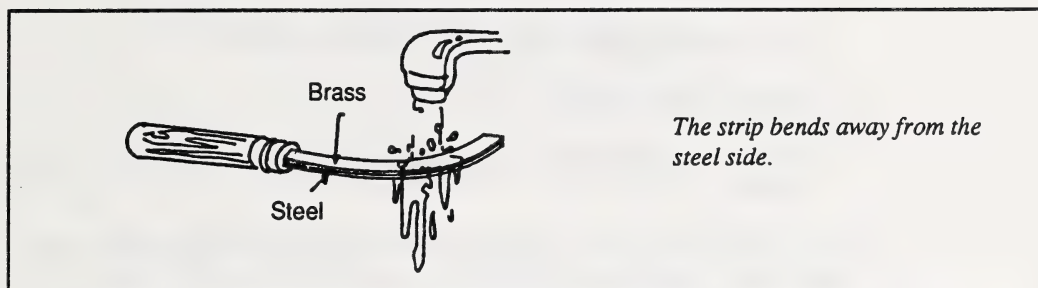
### Observations

### Bimetallic Strip in a Flame





## Bimetallic Strip under Cold Running Water



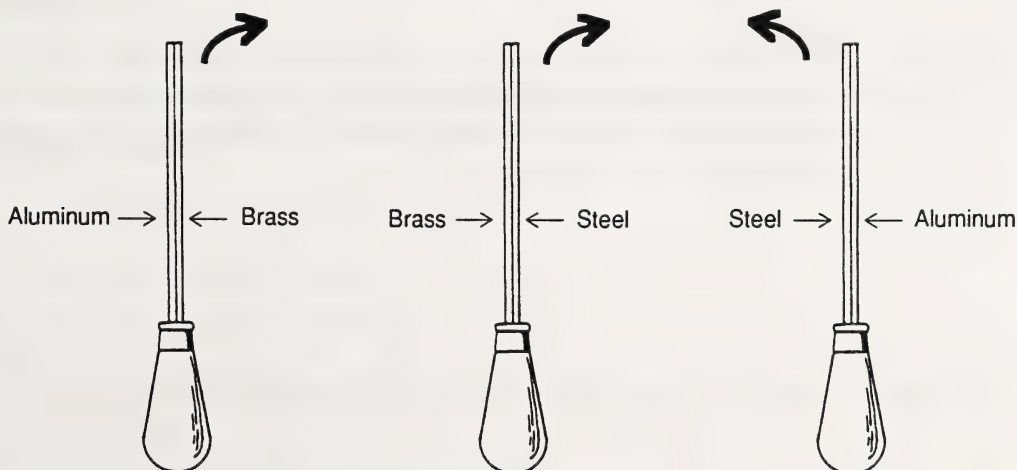
### Questions to Answer

1. Examine the drawing of the scale near the bottom of page 210 of *Science Directions 7*. Explain how you could hold the bimetallic strip so that it could be used with the scale shown.

*The handle of the bimetallic strip should be held firmly or attached securely to something. The other end of the bimetallic strip should be above the scale centered over "Room Temperature." As the bimetallic strip is heated it should bend towards "Warm," and as the bimetallic strip is cooled below room temperature it should bend towards "Cool."*

*The brass side should be on the left; the steel side should be on the right.*

2. Assume that you are responsible for making bimetallic strips. You discover that aluminum expands more than brass, and brass expands more than steel. You make three bimetallic strips as shown.



- a. Draw arrows on the diagrams to show which way each strip will bend when heated.

*See arrows on the previous diagrams.*

- b. Which strip will bend the most?

*The strip made of aluminum and steel will bend the most.*

- c. Explain why you think so.

*The greater the difference in expansion of the materials, the greater the bending.*

3. An oven thermometer uses a coiled bimetallic strip. Examine the drawing of an oven thermometer on the bottom right corner of page 215 of *Science Directions 7*. There are two metals in the bimetallic strip: brass and iron. When heated, the brass expands more than the iron.

How do you think this thermometer works?

*When heated, the bimetallic strip coils more tightly, which turns the toothed wheel and the pointer.*

## Part B

If you were unable to do Part A you should do the following:

- Review the Steps to Follow in Part A to understand how the experiment was done.
- See your learning facilitator for diagrams showing what happens to a bimetallic strip when it is heated in a flame and when it is cooled under cold running water.
- Answer questions 1 to 3 under Part A.

Comments:

If a student chooses Part B, then explain the diagrams given under the Observations for Part A. After the student understands the observations, questions 1 to 3 of Part A are to be answered. Check that these questions have been answered.

**Section 2: Activity 5**

Note: Students are to do either Part A or Part B.

**Part A****Caution**

This activity is to be done under the supervision of the learning facilitator.

**Comments:**

Students will need help in setting up the materials to do this experiment. If a support stand with clamps is not available, some other suitable method to keep the test tubes upright will need to be found. Rigid plastic tubing instead of glass tubing should be inserted through the rubber stoppers.

If arrangements cannot be made for a student to use a school laboratory in order to complete Part A, then Part B should be done. However, you as the learning facilitator may be able to come up with suitable alternatives for Part A. For example, you may want to try using small pop bottles instead of test tubes, plastic straws instead of tubing, putty instead of a rubber stopper and a pot or double boiler instead of a beaker.

**Observations**

*Answers will vary. Students should indicate that the level of liquids in each of the tubes went up as it was heated. Students should also provide a measurement of how much each of the liquids went up.*

**Questions to Answer**

1. a. Do liquids expand when they are heated?

*Yes, they expand when heated.*

- b. How do you know?

*By experimentation, students will have observed that the level of a liquid in a container rises when heated.*

2. a. Do all liquids expand the same amount when they are heated?

*No, some expand more than others.*



- b. How do you know?

*By experimentation, students will have observed a different rise in levels for different liquids that were heated.*

Use the information from the following chart to answer questions 3 and 4.

### Boiling and Freezing Points of Three Liquids

Substance	Boiling Point (°C)	Freezing Point (°C)
mercury	357	- 40
alcohol	78	- 130
water	100	0

3. a. Which liquid would be best suited for a liquid thermometer used for measuring very cold temperatures?

*alcohol*

- b. Why?

*Alcohol can be cooled to a very low temperature before it freezes.*

4. a. Which liquid would be best in a thermometer used to measure the boiling point of water accurately?

*mercury*

- b. Why?

*It is still a liquid at 100°C. (It does not boil until it reaches 357°C.)*

## Part B

If you were unable to do Part A you should do the following:

- Review the Steps to Follow in Part A to understand how the experiment was done.
- See your learning facilitator for the observations that should have been obtained by those students who were able to do the experiment.
- Answer questions 1 to 4 under Part A.

Comments:

Since students were unable to do the experiment for Part A, they will come to you for the observations that should have been obtained. Mention the following observations:

- *The level of the liquids went up in all of the test tubes as they were heated.*
- *The levels for the three liquids were all different after being heated an equal amount of time.*

Check to see that questions 1 to 4 in Part A have been answered.

## Section 2: Activity 6

Note: Students are to do either Part A or Part B.

### Part A: Comparing Thermometers

Comments:

You may need to help the student obtain three different thermometers needed for Part A. The marking of questions 1 and 2 must agree with the selection of thermometers made. Aside from both liquid and spring-type weather thermometers, choices might include specialized thermometers. For example, Thermometer 1 might be a clinical thermometer, Thermometer 2 might be a liquid crystal thermometer, and Thermometer 3 might be an oven thermometer.

Another common type of thermometer is the thermostat. It is used to measure the temperature of an appliance or a room. Students find it interesting to see how a room thermostat works. With your guidance, the cover of a thermostat can be removed to show how a bimetallic strip is used to turn a furnace on or off at a pre-set temperature.

1. Observe each thermometer carefully and fill in the following table.

*The answers in the chart are for a clinical thermometer, a liquid crystal thermometer, and an oven thermometer respectively.*

Characteristic of Thermometer	Thermometer 1	Thermometer 2	Thermometer 3
length (cm)	<i>Answers will vary according to thermometers used. Three answers are provided as examples</i>		
width (cm)			
lowest temperature	35°	35°	0°
type of degrees	Celsius	Celsius	Celsius
substance that expands (solid, liquid, or gas)	liquid	liquid crystal	solid (bimetallic strip)
thermometer's use	for measuring body temperature	for measuring body temperature	for measuring inside temperature of an oven
advantages	<i>It is very accurate in a limited temperature range.</i>	<i>It is easy to use. It is unlikely to be broken.</i>	<i>Answers will vary. (e.g.) It can measure hot temperatures. It is not easily broken.</i>
disadvantages	<i>It measures only a small range of temperature. It has to be sterilized after use.</i>	<i>It is not as accurate as the liquid thermometer.</i>	<i>Answers will vary. There is limited use where precise measurement is needed due to a wide temperature range.</i>

2. For each kind of thermometer, explain why you think the solid or liquid that is used in the thermometer was chosen. In what ways is the material suitable?

*The marking of these questions must agree with the type of thermometers used.*



## a. Thermometer 1:

*A liquid is used because it helps make the thermometer very precise. The liquid in the clinical thermometer expands uniformly between 35°C and 42°C.*

## b. Thermometer 2:

*Liquid crystals are used because they are very easy to read from a colour chart.*

## c. Thermometer 3:

*Solid metals are used because they remain solid at high temperatures.*

## Part B: Special Thermometers for Special Purposes

## 3. Why does a clinical thermometer have a scale that only measures from 35°C to 42°C?

*Human body temperature falls within this range.*

## 4. Why does a clinical thermometer have a constriction?

*The constriction keeps the liquid at its highest level until it is shaken down.*

## 5. Liquid crystal thermometers are sometimes used in place of a liquid thermometer. Why would this be considered a good idea?

*Answers will vary. The following three answers are examples:*

- *The thermometer can be reused without being sterilized.*
- *It is easy to read.*
- *It is not easily broken.*

## 6. What is a disadvantage of a liquid crystal thermometer as compared to a clinical thermometer?

*A liquid crystal thermometer is not as accurate.*

## 7. Name several appliances that you think would be controlled by thermostats?

*Answers will vary. Refrigerators, ovens, electric irons, toasters, hair dryers, and electric frying pans are some examples of appliances controlled by thermostats.*

## 8. How can thermostats be used to conserve energy?

*When a pre-set temperature is reached and no further heating is required, the appliance is switched off.*

9. Describe three examples where it would be good to use a **thermocouple**. (Think of situations where you might want to measure the temperature but where it might not be safe to do so using a regular thermometer.)

*Answers will vary. The following four answers are examples:*

- *in the heating of a hot water tank*
- *in an engine*
- *in a kiln*
- *in a place that is hard to get at, such as a smokestack*

10. What is an optical pyrometer?

*It is a device that measures temperature by analyzing the light given off by an object as it is heated.*

11. What is one advantage of an optical pyrometer over that of a thermocouple?

*It can be used for measuring very high temperatures e.g., temperatures that would melt ordinary metals.*

## Section 2: Follow-up Activities

### Extra Help

Look at the following word list. If you do not know what a word means, look back through this section to find out how the word is used.

### Word List

accurate	Galileo
air	gas
alcohol	hardness
bends	liquid
bimetallic strip	shape
calibrate	solid
Celsius	states
clinical thermometer	strip
compressed	temperature
contract	thermocouple
degrees	thermometer
expand	thermostat
flow	volume

### Crossword Puzzle

Use the word list to complete the crossword puzzle. A few extra words have been added, so think carefully before you pick which word to use.

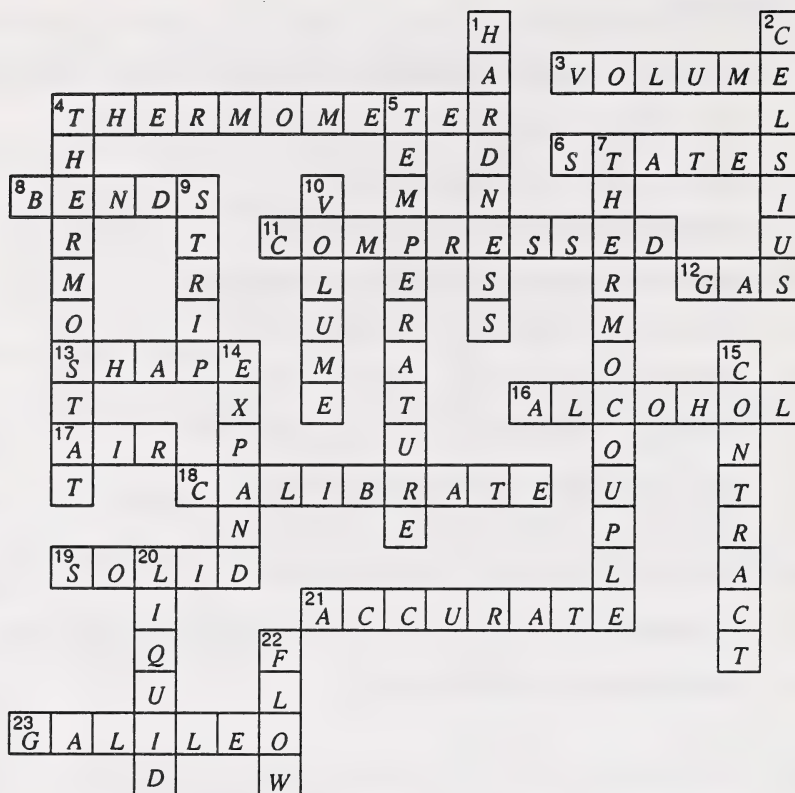
**Across Clues**

3. The amount of space that something takes up is called *volume*.
4. A device that is calibrated in units called degrees is a *thermometer*.
6. Matter can exist in three different *states*.
8. A bimetallic strip *bends* when heated or cooled.
11. Gases can be *compressed*, but liquids and solids cannot.
12. a state of matter that can change shape and volume
13. A solid is the only state of matter that keeps its *shape*.
16. This liquid is coloured before it is used in a thermometer.
17. This is what Galileo used in his first thermometer.
18. You need two fixed points to *calibrate* a thermometer.
19. a state of matter that keeps its shape and volume
21. Thermometers are more *accurate* than your senses to measure temperature.
23. This person made the first thermometer.

**Down Clues**

1. A change in this could indicate a change in temperature.
2. a temperature scale
4. This device will turn a furnace on or off to control the temperature.
5. This is a measure of how hot or cold something is.
7. a thermometer that uses electricity to measure temperature
9. A bimetallic *strip* can be used as a solid thermometer.
10. A change in this could indicate a change in temperature.
14. All three states of matter *expand* when heated.
15. All three states of matter *contract* when cooled..
20. a state of matter that changes shape but keeps the same volume
22. Liquids and gases *flow*, but solids do not.





### Enrichment

### Questions to Answer

1. In which direction did the coloured water move when you took the air thermometer to a warm location?

*The water moved downward.*

2. Explain why it moved in that direction.

*The air expanded into some of the space that had been taken up by the water.*

3. In which direction did the coloured water move when you took the air thermometer to a cool location?

*The water moved upward.*

4. Explain why it moved in that direction.

*The air contracted. The water moved up to take up space that had been taken up by the air.*

5. Explain how you could make a scale for your thermometer.

*Answers will vary. Following is a sample of a satisfactory response:*

*Tape a piece of light-coloured cardboard to the glass tube. Using a calibrated thermometer, measure the actual temperature of the air around the apparatus. Place a small line and a number to show the temperature on the cardboard. Make additional markings by the tube to show the level of the water at different temperatures, taking care to let the apparatus adjust to each new temperature.*

6. What is one advantage of using your air thermometer?

*Answers will vary. The following two answers are examples:*

- *It does not require the use of a special liquid.*
- *It is fairly easy to read.*

7. What is one disadvantage of using your air thermometer?

*Answers will vary. The following three answers are examples:*

- *It is very large and could be cumbersome to use.*
- *It could easily be broken or upset.*
- *It requires the use of some fairly expensive apparatus.*

## Section 2 Assignment

(32 Total Possible Marks)

1. What are the three states of matter? Give two examples of substances in each state of matter. (9)

*Examples will vary.*

- *Solid*      *Examples: ice, wood, steel*
- *Liquid*    *Examples: water, alcohol, oil*
- *Gas*        *Examples: air, oxygen, carbon dioxide*

2. If you were given a substance, describe what you would do to demonstrate which state of matter it was in. (3)

*Observe the material. If it fills whatever container it is in, it is a gas. If it can be poured from one container to another and form a level surface, it is a liquid. If it feels solid to the touch and has a definite shape, it is a solid.*

*Award one mark for distinguishing a solid, one for a liquid, and one for a gas.*

*The answer does not have to be in three separate parts.*

3. Turn to page 211 of *Science Directions 7*. Look at the two diagrams at the top of the page. The diagrams show a paved surface of a highway overpass.

- a. Which illustration represents the paved surface in the summer? (1)

*Illustration A is the one which shows less open space.*

- b. How do you know? (2)

*When the solid bridge is heated, it expands and the spaces between sections become smaller.*

4. A table tennis ball was partly crushed by accident. To restore it to its original shape, Karen put the ball into boiling water for 1 minute. Explain why this method might work. (2)

*The air inside will expand when it is heated and push out the side of the ball.*

5. a. Describe a thermometer made for a special purpose. (2)

*Answers will vary. Students may describe such examples as a clinical thermometer, a thermocouple, or thermostat.*

*Example: A clinical thermometer is a liquid thermometer with a constriction which prevents the liquid from going down unless the thermometer is shaken downwards.*

- b. How is this thermometer different from other thermometers? (2)

*Answers will vary.*

*Example: Other liquid thermometers do not have a constriction.*

- c. What is one advantage of this thermometer? (2)

*Answers will vary.*

*Example: The clinical thermometer provides for the easy and accurate reading of a person's temperature.*

- d. What is one disadvantage of this thermometer? (2)

*Answers will vary.*

*Example: A clinical thermometer is only useful for measuring human body temperature. It is not useful for weather measurements.*

6. What is the difference between a liquid thermometer and an air thermometer? (2)

*A liquid thermometer is based on the expansion of a liquid.*

*An air thermometer is based on the expansion of air.*



7. What is the similarity between a liquid thermometer and an air thermometer? (2)

*Both have something that expands.*

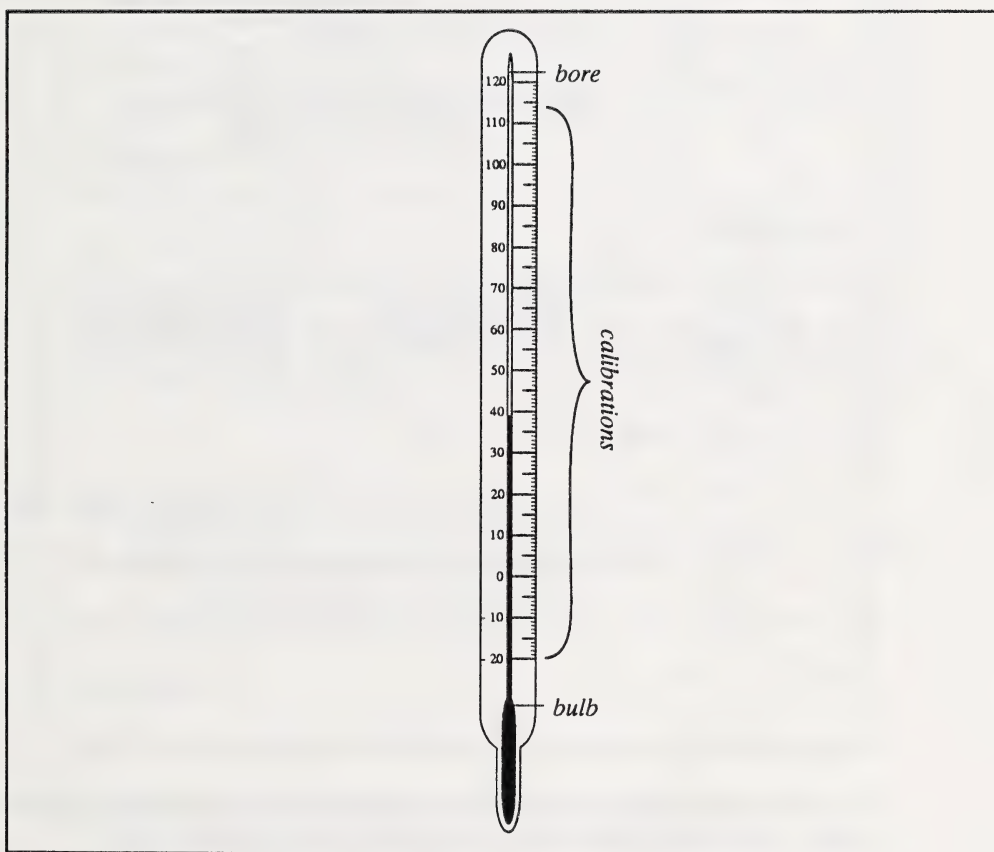
*or*

*Both have a system of markings to measure the temperature.*

*or*

*Both have a bulb as part of the thermometer.*

8. Draw a labelled diagram of a thermometer. Your labels should show the bulb, the bore, and calibrations. (3)



### Section 3: Heat and Temperature

By the end of this section students should be able to

- estimate the final temperature of mixtures of liquids
- distinguish between heat and temperature
- describe temperature and heat in terms of particle motion

#### Section 3: Activity 1

##### Caution

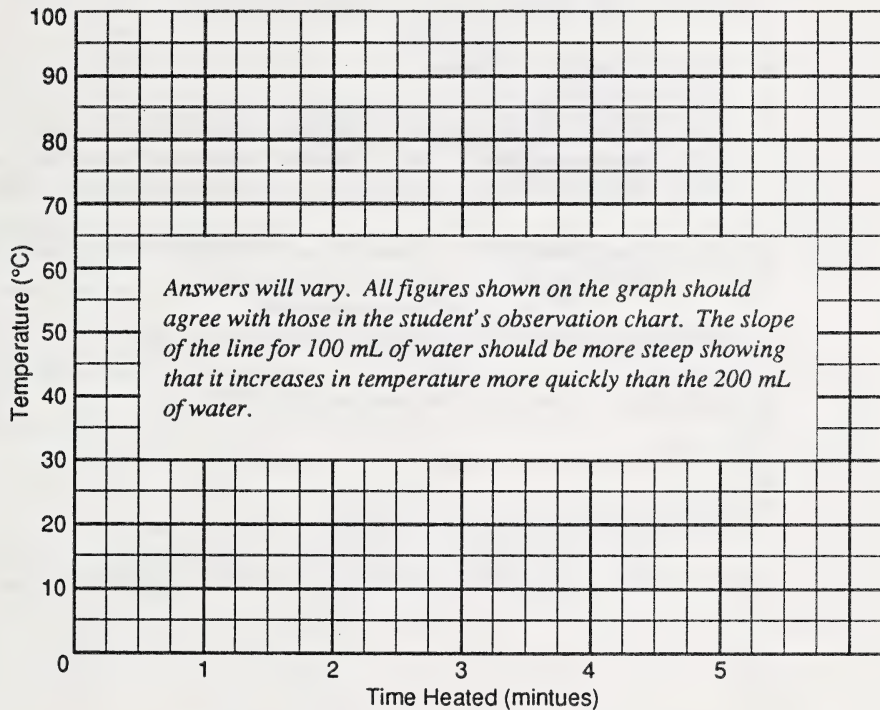
This activity is to be done under the supervision of the learning facilitator.

#### Observations

Time (Minutes)	Temperature (°C) 100 mL of Water	Temperature (°C) 200 mL of Water
0	<i>Answers will vary. After the first minute of heating, the temperature rise in each case will likely be fairly constant. The temperature of the 100 mL of water should rise more quickly than the temperature of the 200 mL of water.</i>	
1		
2		
3		
4		
5		

Now draw a line graph showing the temperature at each time interval for the different amounts of water. Use different colours to show your results for each amount of water.

### Graph One: Temperature Change and Heating Time for Water



#### Questions to Answer

1. a. Was about the same amount of heat added to each sample?

*Yes, it should be about the same for both.*

- b. How do you know?

*Each of them were heated for the same length of time using the same heat source.*

2. Which amount of water had the higher temperature at the end of 5 minutes?

*The 100 mL of water had the higher temperature.*

3. Draw a line on the graph to predict what the temperature readings would be if you had used 300 mL of water. Why did you draw it where you did?

*Answers will vary. Students should in some form indicate the idea that the more water used, the slower it will heat.*

4. a. Do your observations support the idea that heat and temperature are the same?

*No. (They should show that they are different.)*

- b. Give a reason for your answer.

*This is a fairly difficult question that requires abstract thought. Some students will likely need assistance with this question. If heat and temperature were the same, the temperature would go up the same amount whenever the same amount of heat is added.*

5. Imagine that you heated 500 mL of water from 20°C to 50°C. Next you wanted to heat 800 mL of water from 20°C to 50°C. Circle the correct statement.

a. Both samples contain the same amount of energy at 50°C.

b. The 500 mL of water contains more energy at 50°C.

☒ c. The 800 mL of water contains more energy at 50°C.

6. Give a reason for your answer to question 5.

*The more water you have, the more heat it takes to cause a temperature rise.*



## Section 3: Activity 2

**Caution**

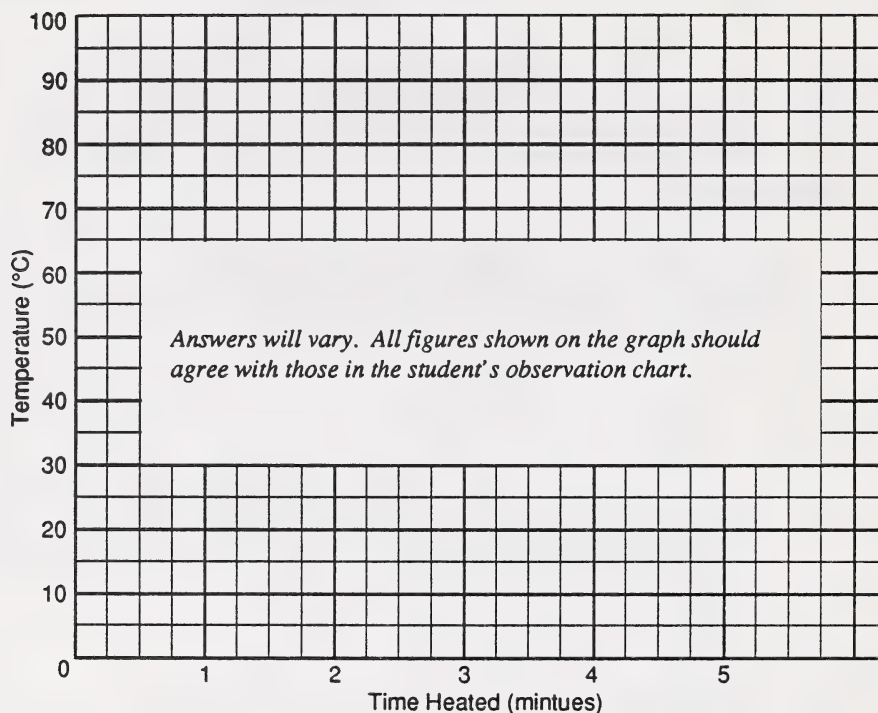
This activity is to be done under the supervision of the learning facilitator.

**Observations**

Time (Minutes)	Temperature of Liquids (°C)		
	Water	Cooking Oil	Glycerine
0	<i>Answers will vary. Results should indicate a more rapid rate of heating for cooking oil and glycerine than for water.</i>		
1			
2			
3			
4			
5			

Now draw a line graph showing the temperature at each time interval for the water. Use different colours to draw lines for cooking oil and for glycerine.

## Graph Two: Temperature Change and Heating Time for Three Different Liquids



### Questions to Answer

1. a. Was the same amount of heat added to each sample?

*Yes, it should be the same for both.*

- b. How do you know?

*Each of them was heated for the same length of time using the same heat source.*

2. Which type of liquid showed the greatest increase in temperature?

*The answer can be either glycerine or cooking oil. Answers may vary slightly with the specific brand of material used. Answers given should agree with the student's experimental results recorded in the observations chart.*

3. Which type of liquid showed the smallest increase in temperature?

*The water would show the smallest increase.*

4. a. Do your observations support the idea that heat and temperature are the same?

*No, they should show that they are different.*

- b. Give a reason for your answer.

*If they were the same, the temperature would have gone up the same amount for each of the liquids.*

5. Imagine that you heated 500 mL of water from 20°C to 50°C. Next you wanted to heat 500 mL of cooking oil from 20°C to 50°C. Circle the correct statement.

- a. Both samples contain the same amount of energy at 50°C.

- ☒ b. The 500 mL of water contains more energy at 50°C.

- c. The 500 mL of cooking oil contains more energy at 50°C.

6. Give a reason for your answer to question 5.

*The water would take longer to heat to this temperature. or  
The water would require more heat to bring it to 50°C.*

### Section 3: Activity 3

Note: Part A is optional, but  
students must do Part B.

#### Part A: Designing an Experiment (Optional)

Using Lavoisier's hypothesis, you can predict that as water freezes, it should lose mass. Design an experiment to test this prediction.

## Materials You Need

List the materials you would need.

*Answers will vary. Check to see that the student's design is a suitable way to test Lavoisier's hypothesis. The following answers are provided as examples:*

- beaker
- hot plate
- water
- thermometer
- several ice cubes
- balance scale

## Steps to Follow

Write the steps in the order you would follow them.

*Step 1: Fill the beaker half full of water.*

*Step 2: Add two or three ice cubes.*

*Step 3: Determine the mass of the beaker and its contents.*

*Step 4: Heat the beaker of water to about room temperature.*

*Step 5: Determine the mass of the beaker and its contents.*

*Step 6: Compare the mass after heating with the mass before heating.*

## Part B: Interpreting an Experiment

1. Why should water lose mass as it turns to ice if Lavoisier's hypothesis is correct?

*It should lose mass because when it freezes, it should lose caloric fluid.*

2. Did Thompson's experiment support Lavoisier's hypothesis?

*No, it did not.*

3. Give a reason for your answer to question 2.

*The mass did not change when some water was frozen. or  
The ice had the same mass as the water.*



### Section 3: Activity 4

1. Describe the particle theory.

*The particle theory states that all matter is made up of tiny particles that are always moving.*

2. Why is the particle theory called a theory instead of a hypothesis?

*It is more than a possible explanation of how matter behaves. So far all the experiments done by scientists support the ideas that all substances are made up of moving particles.*

3. List three variables that are taken into account when discussing the total energy content in a sample of matter.

*The total energy in a sample of matter is accounted for by*

- *temperature (the average speed of particles)*
- *type of matter (the type of particles)*
- *amount of matter (the number of particles)*

4. A kettle and a cup both contain water at 50°C. Use the particle theory to explain why the temperature is the same in both samples of water, even though the kettle has the greater amount of water.

*The temperature is the same because the average energy of the particles is the same in both samples.*

5. Two cups contain the same amount of water. In one cup the water is at 20°C, and in the other it is at 80°C. According to the particle theory, why is the temperature higher in the cup at 80°C?

*The temperature is higher in the cup of water at 80°C because the average energy of the particles is greater.*

6. When the two samples of water are at 50°C, why is the total energy greater in the sample of water in the kettle than in the sample of water in the cup?

*The total energy content is greater in the kettle with water because there is a greater number of particles present.*

7. When two equal amounts of water at different temperatures are mixed, describe the heat transfer that occurs.

*Heat transfers from the warmer water to the cooler water.*

### Section 3: Activity 5

#### Comments:

If an uncalibrated thermometer is not available for the experiment in this activity, then an ordinary laboratory thermometer may be used.

#### Questions to Answer

1. The hot water contained (circle one)
  - a. many more particles than the cold water
  - ☒ b. about the same number of particles as the cold water
  - c. many less particles than the cold water
2. Was the final temperature of the mixture closer to the temperature of the hot water, the cold water, or was it about halfway between the two temperatures?

*It would be about halfway between the two temperatures.*

*The temperature may be slightly less than halfway because some heat is lost to the container and to the surrounding air.*

3. Explain your observation using the particle theory of matter. What happens to the particles of hot water and cold water when they are mixed?

*The particles of hot water are slowed down and the temperature of that water drops.*

*The particles of the cold water speed up and the temperature of that water rises.*

4. a. If you mixed 100 mL of water at 20°C with 100 mL of water at 60°C, what would the final temperature be?

*The temperature would be 40°C, assuming no heat losses to the environment had occurred.*

- b. Give a reason for your prediction.

*The temperature drop for the hot water will be the same as the temperature rise of the cold water.*

### Section 3: Activity 6

#### Comments:

If an uncalibrated thermometer is not available for the experiment in this activity, then an ordinary laboratory thermometer may be used.

### Questions to Answer

1. The hot water contained (circle one)
  - a. many more particles than the cold water
  - b. about the same number of particles as the cold water
  - c. many less particles than the cold water
2. Was the final temperature of the mixture closer to the temperature of the hot water, the cold water, or was it about halfway between the two temperatures?

*The final temperature was closer to the hot water temperature.*

3. a. If you mixed 100 mL of water at 20°C with 200 mL of water at 60°C, what would the final temperature be?

*The final temperature would be about 50°C.*

- b. Give a reason for your prediction.

*When unequal amounts of water are mixed, the final temperature will be nearer the temperature of the greater amount of water.*

### Section 3: Activity 7

Comments:

If an uncalibrated thermometer is not available for the experiment in this activity, then an ordinary laboratory thermometer may be used.

### Questions to Answer

1. Was the final temperature of the mixture closer to the temperature of the hot water, the cold cooking oil, or was it about halfway between the two temperatures?
2. a. If you mixed 100 mL of cooking oil at 20°C with 100 mL of water at 60°C, approximately what would the final temperature be?

*50°C*

- b. Give a reason for your prediction.

*The temperature of the oil and water mixture in Activity 7 was closer to the temperature of the water.*

### Section 3: Follow-up Activities

#### Extra Help

In each of the following described situations, state in which direction the heat will flow.

1. Water at 30°C is poured onto your back (37°C).

*Heat will flow from your back to the water.*

2. 500 mL of water at 25°C is mixed with 10 mL of water at 90°C.

*Heat will flow from the water at 90°C to the water at 25°C.*

3. A spoon at 25°C is placed into a cup of water at 5°C.

*Heat will flow from the spoon at 25°C to the water at 5°C.*

Use the following words to fill in the blanks for questions 4 to 10. You may use a word as many times as needed. You will not use all the words.

#### Word List

colder	heat	same
different	hotter	slower
faster	more	stationary
fewer	moving	temperature
	particles	

4. Matter is made up of small *particles*.
5. Heat moves from *hotter* substances to *colder* substances.
6. Particles of matter are always *moving*.
7. 100 mL of water has *more* particles than 25 mL of water.
8. Water at 35°C has *faster* particles than water at 25°C.
9. 100 mL of oil at 35°C has *more* total energy than 50 mL of oil at 35°C.
10. 35 mL of water at 15°C has the same *temperature* as 200 mL of cooking oil at 15°C.



For questions 11 and 12 you may wish to refer to *Graph One: Temperature Change and Heating Time for Water* in Activity 1 and *Graph Two: Temperature Change and Heating Time for Three Different Liquids* in Activity 2. Use the particle theory of matter to explain the questions.

11. Why does the temperature of 200 mL of water change more slowly than the temperature of 100 mL of water when heated?

*Because there are more particles of water in 200 mL, it requires more heat to change the temperature than for 100 mL.*

12. (Optional) Why does cooking oil heat up faster than water?

*Less heat is required to change the temperature of the oil than for the water.*

### Enrichment

Note: Students may do either Part A or Part B, or they may do both Part A and Part B.

### Part A: Temperature Change During Melting

#### Observations

*The basic form of the chart should be as shown at the right. The actual temperatures recorded will vary, but they should reflect a rapid increase to 0°C followed by a long period of constant temperature. The temperature begins to increase again after all the ice is melted.*

Time (in minutes)	Temperature (°C)
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

## Questions to Answer

1. What change of state occurs in this activity?

*Melting takes place.*

2. This change of state needs heat energy. Where did the heat energy come from?

*The heat comes from the surrounding air.*

3. What happens to the temperature during this change of state?

*The temperature stays the same while melting.*

4. Why is the melting point of ice a good fixed point to use when calibrating a thermometer?

*Answers will vary. This is a good temperature to use because it involves one of the most common materials we use.*

## Part B: Predicting Based on Theory

Suppose you have two cups of water. Cup 1 contains 100 mL of water at 10°C. Cup 2 contains 100 mL of water at 30°C. Use this information to answer questions 5 to 8.

5. Which is at the higher temperature?

*The water at 30°C is the higher temperature.*

6. a. Which cup contains the most energy?

*The cup at 30°C contains the most energy.*

- b. Give a reason for your answer.

*The amount of water is the same so there are the same number of particles, but the particles at 30°C have more energy.*

7. a. From which water would the heat move if the two were mixed?

*Heat would move from the hot water to the cooler water.*

- b. Give a reason for your answer.

*Answers will vary. The following answer is an example:  
The particles in the hot water are moving faster and have more energy.*

8. a. If the two were mixed, the final temperature would be (circle one)

i. closer to  $30^{\circ}\text{C}$  than to  $10^{\circ}\text{C}$

ii. closer to  $10^{\circ}\text{C}$  than to  $30^{\circ}\text{C}$

iii. about halfway between  $30^{\circ}\text{C}$  and  $10^{\circ}\text{C}$

- b. Give a reason for your answer.

*There were equal volumes of water. The temperature gained by the cold water was the same as the temperature lost by the warm water.*

Suppose you have two more cups of water. Cup 3 contains 300 mL of water at  $10^{\circ}\text{C}$ . Cup 4 contains 100 mL of water at  $10^{\circ}\text{C}$ . Use this information to answer questions 9 to 12.

9. Which is at the higher temperature?

*They are both at the same temperature.*

10. a. Which cup contains the most energy?

*The cup with 300 mL of water contains the most energy.*

- b. Give a reason for your answer.

*There are more particles in 300 mL of water.*

11. a. From which water would the heat move if the two were mixed?

*There would not be a movement of heat.*

- b. Give a reason for your answer.

*The water is at the same temperature so there would be no movement of heat.*

12. Predict the final temperature if you were to mix the two.

*The final temperature would be  $10^{\circ}\text{C}$ .*

Suppose you have another two cups. Cup 5 contains 100 mL of cooking oil at  $10^{\circ}\text{C}$ . Cup 6 contains 100 mL of water at  $30^{\circ}\text{C}$ . Use this information to answer questions 13 to 16.

13. Which is at the higher temperature?

*The water at  $30^{\circ}\text{C}$  is at the higher temperature.*

14. a. Which cup contains the most energy?

*Cup 6, containing water at 30°C, contains the most energy.*

- b. Give a reason for your answer.

*The water is at a higher temperature.*

*Also, water holds a greater amount of heat than oil does.*

15. a. From which substance would the heat move if the two were mixed?

*The heat would move from the water.*

- b. Give a reason for your answer.

*The water is at a higher temperature.*

16. If the two were mixed, the final temperature would be (circle one)

- ☒ a. closer to 30°C than to 10°C  
b. closer to 10°C than to 30°C  
c. about halfway between 30°C and 10°C

### Section 3 Assignment

(26 Total Possible Marks)

Comments:

The best answers to the multiple choice questions for Assignment 3 are circled. Check these against the answers the student gave on the response pages.

For questions 1 to 5, use the following information.

100 mL of water was obtained from a hot water tap and then poured into a cup. The temperature of the water was measured and found to be 75°C. A second sample of water was taken from a cold tap. 100 mL of cold water was poured into another cup. Its temperature was measured and found to be 15°C. The two samples were mixed by pouring the cold water into the hot water.



1. Which sample contained more energy? (Write the letter of the best answer on the response page.) (1)

- a. the water at  $15^{\circ}\text{C}$
- ☒ b. the water at  $75^{\circ}\text{C}$
- c. both contained the same amount of energy
- d. the energy content cannot be compared with this amount of information

2. Give a reason for your answer to question 1. (2)

*For the same amount of water, the energy is greater when the temperature is higher.*

3. Which sample had the higher temperature? (Write the letter of the best answer on the response page.) (1)

- a. the water at  $15^{\circ}\text{C}$
- ☒ b. the water at  $75^{\circ}\text{C}$
- c. both were at the same temperature
- d. the temperatures cannot be compared with this amount of information

4. When the samples are mixed, in what way will heat energy move? (Write the letter of the best answer on the response page.) (1)

- ☒ a. to the water at  $15^{\circ}\text{C}$
- b. to the water at  $75^{\circ}\text{C}$
- c. heat energy will not move between the samples
- d. impossible to predict with this amount of information

5. a. Give a reason for your answer to question 4. (2)

*Heat energy moves from hotter materials to cooler ones.*

- b. Predict the final temperature of the mixture. State why you chose this temperature. (2)

*The final temperature should be  $45^{\circ}\text{C}$ , assuming no heat losses to the environment had occurred. Since the volumes of the hot and cold water were equal, the final temperature should be half way between  $15^{\circ}\text{C}$  and  $75^{\circ}\text{C}$  when mixed.*

For questions 6 to 10, use the following information.

100 mL of cooking oil was heated on a stove until the temperature was 50°C. The hot oil was removed from the stove. 50 mL of cold cooking oil, at 20°C, was poured into the hot oil.

6. Which sample contained more energy? (Write the letter of the best answer on the response page.) (1)

- a. the cooking oil at 20°C
- ☒ b. the cooking oil at 50°C
- c. both contained the same amount of energy
- d. the energy content cannot be compared with this amount of information

7. Give a reason for your answer to question 6. (2)

*There was more oil and the temperature was higher.*

8. Which sample had the higher temperature? (Write the letter of the best answer on the response page.) (1)

- a. the cooking oil at 20°C
- ☒ b. the cooking oil at 50°C
- c. both had the same temperature
- d. the temperatures cannot be compared with this amount of information

9. When the samples are mixed, heat energy should move (Write the letter of the best answer on the response page.) (1)

- ☒ a. to the cooking oil at 20°C
- b. to the cooking oil at 50°C
- c. heat energy will not move between the samples
- d. impossible to predict with this amount of information

10. Give a reason for your answer to question 9. (2)

*Heat energy moves from hotter materials to cooler ones.*

For questions 11 to 15, use the following information.

200 mL of water at 45°C were in Cup 1. 300 mL of cooking oil at 45°C were in Cup 2. The two were mixed by pouring them both into Cup 3.

11. Which sample contained more energy? (Write the letter of the best answer on the response page.) (1)

- a. the water in Cup 1
- b. the cooking oil in Cup 2
- c. both contained the same amount of energy
- ☒ d. the energy content cannot be compared with this amount of information

12. Give a reason for your answer to question 11. (2)

*There are different amounts of different liquids.*

13. Which sample had the higher temperature? (Write the letter of the best answer on the response page.) (1)

- a. the water in Cup 1
- b. the water in Cup 2
- ☒ c. both had the same temperature
- d. the temperatures cannot be compared with this amount of information

14. When the samples are mixed, heat energy should move (Write the letter of the best answer on the response page.) (1)

- a. from the water into the oil
- b. from the oil into the water
- ☒ c. heat energy will not move between the samples
- d. impossible to predict with this amount of information

15. Give a reason for your answer to question 14. (2)

*There is no temperature difference between the two materials.*

16. Describe the difference between temperature and heat. (3)

*Temperature is a measurement of the average energy of a substance, or how hot or cold it is. Heat is the amount of energy in a material or the energy that is transferred from one material to another.*

## Section 4: Sources of Heat

By the end of this section students should be able to

- identify sources of heat
- identify advantages and disadvantages of heat sources
- compare the energy content of fuels
- compare the energy content of foods

## Section 4: Activity 1

Note: Part A is optional, but students must do Part B.

Comments:

Although Part A is optional, it is suggested that students do attempt to complete Part A under the supervision of a learning facilitator. Students are often quite surprised at the amount of heat that is contained in a peanut and in a walnut.

## Part A: Measuring Heat Content of Foods (Optional)

### Caution

This activity is to be done under the supervision of the learning facilitator.

## Observations

Type of Nut	Starting Temperature of Water (° C)	Final Temperature of Water (° C)
peanut	<i>Answers will vary.</i>	
walnut		



## Questions to Answer

1. What was done so that the energy in the food could be used to heat water?

*The food was burned. The heat of the flame caused the water to be heated.*

2. How is food similar to fuels such as wood or gasoline?

*They both contain energy.*

3. What happens to the temperature when you apply more heat to a sample of water?

*The temperature of the water rises.*

4. What was the temperature change for the water heated by a peanut?

*Answers will vary. Check with the results stated in the observations chart for the peanut. To obtain the answer the student needed to subtract the starting temperature of the water from the final temperature of the water.*

5. What was the temperature change for the water heated by a walnut?

*Answers will vary, but should correspond with the information given in the student's observation chart.*

6. a. Which nut contains the most energy?

*Answers will vary.*

- b. Give a reason for your answer.

*The temperature rise for the heated water will have been greater for this nut than for the other.*

## Part B: Interpreting Heat Content of Foods

By using information in the chart which follows, you can calculate how much energy is contained in a serving of several foods. If you were on a diet to lose weight, you should choose foods lower in energy content. For example, which would contain more energy – a serving of peanut butter or a banana? The peanut butter has more energy for each gram, but a banana is much larger. Use the chart to answer questions 7 to 14.

**Food Energy Content**

Food	Energy Content (Joules per Gram)	Mass of a Typical Serving (Grams)
chocolate milkshake	4 950	400
fried egg	7 350	46
wiener	3 200	37
peanut butter	24 750	16
banana	3 850	114
apple pie (slice)	10 700	158
chocolate bar	19 600	30

7. Calculate the total energy content of one serving of each food. The first one has been done for you.

*chocolate milkshake*       $4950 \text{ J/g} \times 400 \text{ g} = 1\,980\,000 \text{ J} = 1980 \text{ kJ}$

fried egg       $7350 \text{ J/g} \times 46 \text{ g} = 338\,100 \text{ J} = 338.1 \text{ kJ}$

wiener       $3200 \text{ J/g} \times 37 \text{ g} = 118\,400 \text{ J} = 118.4 \text{ kJ}$

peanut butter       $24\,750 \text{ J/g} \times 16 \text{ g} = 396\,000 \text{ J} = 396.0 \text{ kJ}$

banana       $3850 \text{ J/g} \times 114 \text{ g} = 438\,900 \text{ J} = 438.9 \text{ kJ}$

apple pie (slice)       $10\,700 \text{ J/g} \times 158 \text{ g} = 1\,690\,600 \text{ J} = 1690.6 \text{ kJ}$

chocolate bar       $19\,600 \text{ J/g} \times 30 \text{ g} = 588\,000 \text{ J} = 588.0 \text{ kJ}$

8. List the foods from greatest to least energy content for a serving.

greatest energy content	<i>chocolate milkshake</i>
	<i>apple pie</i>
	<i>chocolate bar</i>
	<i>banana</i>
	<i>peanut butter</i>
	<i>fried egg</i>
least energy content	<i>wiener</i>

9. Which food has the highest energy in one gram?

*peanut butter*

10. Which food has the least energy in one gram?

*wiener*

11. Which food has the highest energy in one serving?

*chocolate milkshake*

12. Which food has the least energy in one serving?

*wiener*

13. a. If you had not eaten for a long time and needed energy, which serving of food would give you the most energy?

*the chocolate milkshake*

- b. Why?

*The energy content of one serving is very high.*

14. a. If you are on a diet, which serving of these foods would you choose to eat?

*You might consider the wieners.*

- b. Why?

*The wieners have a low energy content.*

The energy from burning fuels is used to heat homes, cook food, and operate cars. Some fuels are solid like wood and coal, some are gas like natural gas, and others are liquid like gasoline and kerosene.

The energy stored in fuels is measured in much the same way as the energy content of food. You measure the temperature increase of water produced by burning the fuel. Scientists collect data on various types of fuels so that comparisons can be made among the different types of fuels. The higher the energy content of a fuel, the more heat it produces. Use the Fuel Energy Content chart which follows to answer questions 15, 16, and 17.

### Fuel Energy Content

Fuel	Energy Content (Joules per Gram)
coal (solid)	28 000
gasoline (liquid)	44 000
kerosene (liquid)	43 000
methane (gas)	49 000
ethane (gas)	44 000

15. Which fuel provides the most energy for each gram?

*methane*

16. Which fuel provides the least energy for each gram?

*coal*

17. Compare the values for fuels and those for foods. In general, which have a higher energy content – foods or fuels?

*Fuels generally have a higher energy content.*

### Section 4: Activity 2

#### Questions to Answer

1. What happened to the temperature of the nail?

*The temperature increased.*



2. Predict what would happen if you increased the force of the nail against the brick by pressing harder.

*Answers will vary. It is likely that the temperature rise would be greater.*

3. Give a reason for your prediction.

*Answers will vary. The friction between the nail and the brick is greater if there is more pressure.*

4. Describe a situation where heat produced by friction could be harmful.

*Answers will vary. The following answer is an example:  
If parts of a machine rub together without being oiled, they could wear out.*

5. Describe a situation where heat produced by friction could be useful.

*Answers will vary. The following answer is an example:  
When you strike a match, the friction of the match helps by making the match start to burn.*

### Questions to Answer

6. What happened to the temperature of the paper clip?

*The temperature increased.*

7. Use the particle theory of matter to explain what happened to the temperature during bending.

*The particles in the paper clip move back and forth more quickly as a result of the bending.*

### Questions to Answer

8. What happened to the temperature of the block?

*The temperature increased.*

9. Give a reason for the change in temperature.

*The friction of the hammer against the wood caused the temperature to rise.*

### Section 4: Activity 3

1. What are some sources of chemical energy? Name three foods and three fuels that are sources of chemical energy.

*Answers will vary. The following answers are examples:*

#### Foods

- *bread*
- *potatoes*
- *sugar*

#### Fuels

- *coal*
- *oil*
- *natural gas*

2. What are the three main sources of electrical energy?

- *water power*
- *natural gas*
- *coal*

3. Describe two examples in which electrical energy is used as a source of heat.

*Answers will vary. The following two answers are examples:*

- *Electricity is used to heat a toaster.*
- *Electricity is used in an electric kettle.*

4. Why is geothermal energy sometimes used as a source of heat?

*It is sometimes used because of its availability. Geothermal energy is used in areas where hot materials from inside the earth make their way to the surface (for example, in parts of Iceland, New Zealand, Italy, and the northwestern United States). Also, where it is available, it may be more economical to use geothermal energy than other sources of energy.*

5. List several changes that would have to be made to your home in order for you to use solar energy as the major source of heat.

*Answers will vary. Some of the changes that might be suggested include*

- *having more south-facing windows*
- *improving the insulation of the house*
- *using solar collectors*

## Section 4: Follow-up Activities

### Extra Help

Each of the following types of energy are sources of heat:

- chemical energy
- electrical energy
- geothermal energy
- solar energy
- mechanical energy

1. Describe how you could heat water three different ways to make tea. Use a different type of energy for your source of heat for each method.

*Answers will vary. The following answers are examples:*

- Energy Source:  
Method 1

- *wood (chemical energy)*  
*Use a wood fire to heat a kettle of water.*

- Energy Source:  
Method 2

- *electricity (electrical energy)*  
*Use an electric kettle to heat the water.*

- Energy Source:  
Method 3

- *natural gas (chemical energy)*  
*Use a gas stove to heat a kettle of water.*

2. Describe one advantage and one disadvantage for each method.

*Answers will vary. The following answers are examples.*

- a. Method 1  
advantage:

*The wood fuel is available in many areas.  
You don't need very much special equipment.*

disadvantage:

*Using wood fuel may lead to the loss of forests.  
Wood is not as convenient to use as some other fuels.*

- b. Method 2  
advantage:

*Electricity is very convenient to use.*

disadvantage:

*A source of electrical energy is needed.  
A way of bringing the electrical energy to where it is to be used is also needed.*

- c. Method 3  
advantage:

*Natural gas is a convenient fuel to use.*

disadvantage:

*Natural gas stoves use up a valuable natural resource.*

### Enrichment

#### Caution

This activity is to be done under  
the supervision of the learning facilitator.



## Observations

Type of Candle	Starting Temperature (°C)	Final Temperature (°C)
birthday	<i>Answers will vary. The large candle will increase the temperature of the water more than the birthday candle.</i>	
large		

## Interpretations

100 mL of water were heated by each candle. Every millilitre has a mass of 1 g. This means that each candle heated 100 g of water.

1. Since it takes 4.2 J of heat energy to raise the temperature of 1 g of water by 1°C, how many joules of heat energy would be needed to raise the temperature of 100 g of water by 1°C?

*420 J of heat energy would be needed. e.g.  $100\text{ g} \times 4.2\text{ J/g} = 420\text{ J}$*

2. Check your observation chart. The temperature of the water in each sample likely increased by more than 1°C. Find the temperature change in each case by subtracting the starting temperature from the final temperature.

*Answers will vary. They must agree with the results in the student's observation chart. The following answers are examples.*

- a. change in temperature for birthday candle 4°C
  - b. change in temperature for large candle 8°C
3. To calculate the number of joules of heat that are transferred from each candle to the 100 g samples of water, you need to multiply the answer you obtained for question 1 by the changes in temperature you obtained for question 2.

*Answers will vary according to student's answers given to question 2. For the examples given, the answers would be*

- a. Show the calculations for the birthday candle.

$$420\text{ J/}^{\circ}\text{C} \times 4^{\circ}\text{C} = 1680\text{ J}$$

- b. Show the calculations for the large candle.

$$420\text{ J/}^{\circ}\text{C} \times 8^{\circ}\text{C} = 3360\text{ J}$$

4. How many joules of heat did the birthday candle transfer to the water in 1 minute?

*Answers will vary, but will be half the results given for question 3. a. since the water in investigation was heated for 2 minutes. e.g.  $1680\text{ J} \div 2 = 840\text{ J}$*

5. How many joules of heat did the large candle transfer to the water in 1 minute?

*Answers will vary, but will be half of the result given for question 3. b. since the water in the investigation was heated for 2 minutes. e.g.  $3360\text{ J} \div 2 = 1680\text{ J}$*

6. Describe how you could calculate the number of joules of energy that 1 gram of the large candle contains.

*You would need to determine the mass of the candle before and after burning. Then subtract to calculate the number of grams of the candle that burned. The number of joules is then divided by the number of grams.*

## Section 4 Assignment

(30 Total Possible Marks)

1. For each example, write the type of energy (chemical, mechanical, electrical, solar, or geothermal) which is producing heat. Write your answers in the space beside each letter on the following response page. (20)
  - a. You rub your hands together when they are cold. *mechanical*
  - b. Water at Banff Hot Springs is heated naturally. *geothermal*
  - c. Your body stays at  $37^{\circ}\text{C}$  even though the temperature around your body is colder. *chemical*
  - d. It feels hot outside. *solar*
  - e. You burn logs in a fireplace or wood stove. *chemical*
  - f. You barbecue a hamburger. *chemical*
  - g. As you go down in a mine, you feel the temperature increasing. *geothermal*
  - h. Icicles melt on a warm day. *solar*
  - i. Car tires heat up after a long drive. *mechanical*
  - j. A nail heats up after being hit with a hammer. *mechanical*

- k. Melted rock pours out of a volcano. *geothermal*
- l. The sidewalk feels warm on a summer day. *solar*
- m. A greenhouse is used to grow tomatoes during the winter. *solar or chemical*
- n. The inside of a car becomes very hot while it is parked on a hot day. *solar*
- o. You use an electric toaster to make your breakfast. *electrical*
- p. You must strike a match to start it burning. *mechanical*
- q. Water from the Earth's oceans and lakes evaporates, forming clouds. *solar*
- r. A hot iron is used to press clothes. *electrical*
- s. The brakes on a truck become very hot after going down a long hill. *mechanical*
- t. The blade of an axe becomes hot as you chop wood. *mechanical*
2. The unit for measuring heat is called a joule. This is the same unit that is used for measuring the amount of electricity you use for your house. Why is the same unit used for heat as for electricity? (2)

*They are both measures of energy.*

3. Heat energy can be produced from the following types of energy: solar, chemical, mechanical, electrical, and geothermal.

Choose **one** of these sources of heat and describe the advantages and disadvantages of the source of heat.

*Answers will vary, according to the source of heat energy chosen. An example using solar energy is given here.*

Advantages: (2)

*Answers will vary.*

*Example: The main advantages of solar energy are that it is free, it is renewable, and its use does not result in a major impact on the environment.*

Disadvantages: (2)

*Answers will vary.*

*Example: Solar energy is not available at night and is only partially available on cloudy days. Solar energy needs to be converted to other forms of energy to be useful in most applications.*



4. Describe how you could compare the energy content of a marshmallow and a spoonful of sunflower seeds. (4)

*Answers will vary in detail but should be based on the following principles:*

- *Use an equal mass of each of the two materials to heat identical containers of liquid with the same starting temperature.*
- *Compare the temperature rise of the liquid after each of the two energy sources has finished burning.*

Comment:

A final grading for Module 4 can be determined at this point.







This booklet cannot be purchased separately; the  
Learning Facilitator's Manual is available  
only as a complete set.



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